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THE IMPACT OF CREDIT, PRICES, TECHNOLOGY, AND EXTENSION ON FERTILIZER DEMAND IN RAINFED AREAS IN THE PHILIPPINES*

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INTRODUCTION

A major objective of supervised credit programs in the Philippines is to accelerate adoption of the new seed-fertilizer technology in rice. Even prior to the nationwide institution of supervised credit programs, the spread of modern varieties has been remarkably rapid. By the early 1970's just 5 years after their initial release, 50 percent of the rice areas were planted with the modern varieties and the reasons for non-adoption in other areas are well understood [4, 8]. Actual fertilizer application, however, has lagged behind projected levels. Average use is currently about 125 kg/ha in contrast to "recommended" levels of 250 kg/ha.1/

It is generally believed that financial constraint impedes higher fertilizer use. Previous attempts to identify the impact of credit on productivity and input use have been primarily descriptive comparing their values before and after or with and without borrowing.2/ These studies, however, have not adequately resolved the attribution problem of separating the impact of

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1/ It should be recognized that "recommended" levels tend to reflect the government objective of maximizing yield per hectare as opposed to the farmer objective of maximizing profit per hectare subject to other constraints such as risk.

2/ For a review of the methodological problems associated with these studies, see David and Meyer [6].

loans from other factors simultaneously affecting fertilizer use such as prices, technology, extension, and so forth. Furthermore, most of these studies have focused mainly on irrigated farms partly because these are typically considered as priority areas. Yet, nearly three-fourths of the rice areas in the Philippines is classified as unirrigated -- 47 percent as rainfed and 27 percent as upland.[3/] These areas are cultivated by the lower income segment of the farming population.

In this paper, we quantify the relative contribution of credit, prices, technology, and extension in explaining the changes in fertilizer demand per hectare in rainfed rice areas in the Philippines. A conceptual framework for analyzing fertilizer demand is presented first. The next section describes the data and empirical model. The third section presents the statistical estimate of the fertilizer demand function and the relative contribution of each factor in fertilizer demand. The policy implications of our results are discussed in the final section.

CONCEPTUAL FRAMEWORK

The demand function for fertilizer can be derived from the condition of farm profit maximization. Assume a neo-

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3/ Upland area is characterized by unbunded fields where water is not impounded. Rainfed fields are puddled to form the typical rice paddy.

classical world of perfect markets (including capital markets) and perfect knowledge of production and price relationships (certainty). Given production technology, $Y = f(F,...)$, where output depends on fertilizer and other inputs; fertilizer and output prices, P_f, P_r, respectively, profit is maximized by using fertilizer at a level which equates its marginal product to the ratio of fertilizer and output price assuming all other inputs are held constant (Figure 1a). Demand for fertilizer therefore depends on its own price, prices of other related inputs, and price of output (Figure 1b).

At the farm level, varying degrees of imperfections in markets and knowledge exist. In terms of Figure 1, farmers may be facing different fertilizer response functions $f(F)$, $f^1(F)$, and so forth, and correspondingly different demand curves for fertilizer $g(F)$, $g^1(F)$. These may be explained by differences in technology (e.g., modern vs. traditional seeds), environmental factors (water supply, soil quality, etc.), levels of other inputs related to fertilizer (organic fertilizer), and level of technical knowledge.

Farmers may also differ in abilities to maximize profits as determined by attitudes towards risk, managerial capacity, initial level of liquidity constraint, and conditions in the financial market. The role of the latter two factors is frequently ignored and thus needs further explanation. When internal farm-household saving is limited, actual input use (F^a) may be lower than optimal levels (F^*). In effect, the

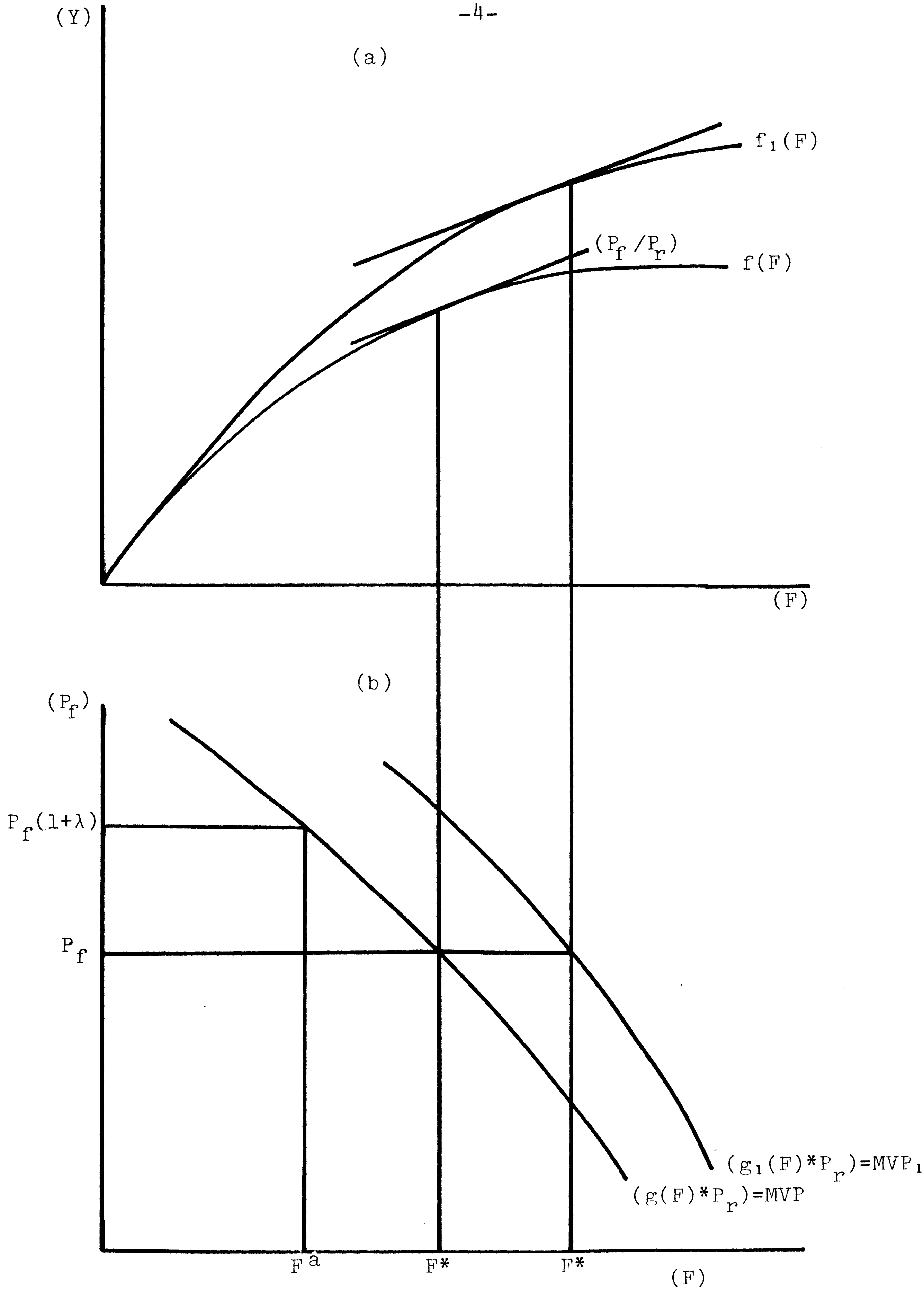

Fig. 1 - Hypothetical fertilizer response functions (a) and corresponding fertilizer demand functions (b).

farmer faces a higher effective cost of fertilizer $P_f(1+\lambda)$, where λ represents marginal time preference for present over future consumption, opportunity cost of own capital, or effective cost of borrowing. The effective cost of fertilizer should therefore reflect not only its market price but a liquidity constraint measure.

Empirical models of fertilizer demand, especially when estimated with farm-level data, must take these other factors into account. In this study, we have a unique opportunity to examine the effects of potential policy instruments -- prices, extension, and credit -- in raising fertilizer demand -- among rainfed farmers based on the evaluation study of the Rainfed-Upland Rice Project (RURP) and Masagana 99 (M99) Program in Bulacan and Nueva Ecija conducted by the Agricultural Economics Department of the International Rice Research Institute (IRRI). This paper is an extension of the earlier studies on the impact of that project [3, 7].

THE DATA AND EMPIRICAL MODEL

In 1971, the government of the Philippines and the IRRI jointly initiated an applied research project in rainfed and upland rice (RURP) in four municipalities of Bulacan (Sta. Maria, San Rafael, San Ildefonso, San Miguel) and one municipality in Nueva Ecija (Gapan). From 1971 to 1973, trial plots numbering between 118 and 246 each crop season were established to demonstrate the impact of experimental application of nitrogen, varieties, stand establishment, herbicides, insecticides, and cultural management. Each trial plot was inspected by the technicians at least 3 times per week and farmer group visits were arranged. The high yields obtained on the rainfed trial plots (4-5 tons/ha compared to average farmer yields of 1-2 tons/ha) during the first year despite severe drought and tungro infestation convinced researchers that the results could be safely recommended to the farmers in the area.

In 1972, a pilot extension-supervised credit program called Masagana 99 (M99) was started in Bulacan to encourage adoption of the new package of cultural practices. Encouraged by the reported average yields of over 4 tons/ha, this was extended on a nationwide basis as an attempt to recover from the drop in rice production due to bad weather and disease and insect infestation. At the national level, however, the emphasis on the M99 Program was shifted to the irrigated areas and the intensive applied research and extension being tested in the RURP were abondoned. The extension component was limited to the joint preparation of a farm budget plan by the farmer and technician and follow up farm visits by the latter. In 1974, the M99 Program was also used as a vehicle for subsidizing fertilizer price for rice farming when world prices of fertilizer quadrupled as a result of the oil crisis in 1973.

In order to evaluate the changes occuring in the pilot project area, the Agricultural Economics Department of IRRI conducted an initial farm survey in 1971 as the project was starting and follow-up surveys in 1974 and 1977. These surveys provide a basis for determining changes in production practices and inputs, and for identifying those factors accounting for the changes in rice production. The final survey was made after the project activities were terminated because this type of farmer response and acceptance of new technology often is not realized immediately.

The survey covered six out of the 23 villages with RURP demonstration plots and another six villages without a demonstration plot but in the general vicinity of the sample RURP villages. A sample of 230 farmers for 1971 and 1974 and 199 for 1977 were interviewed, representing about 20% of the farmers in the selected villages. The questionnaire was designed to monitor the changes in yields, modern inputs, and management practices such as methods of transplanting, weeding, and so forth. A few questions on credit use were asked, but these were not emphasized in the survey as well as in previous analysis. It should be noted, therefore, that the formulation of the empirical model was partly influenced by data availability.

Two alternative empirical specifications of fertilizer demand function were estimated.

$$(1)\quad \log F = \log \beta_0 + \beta_1 \log P_{fr} + \beta_2 \log O + \beta_3 M + \gamma_1 S_1 + \gamma_2 S_2 + \sigma_1 E_1 + \sigma_2 E_2 + \beta_4 \log H + \delta_1 C_i + \delta_2 C_f + \omega_1 T_\ell + \omega_2 T_o + \alpha D + \beta_5 V + \phi_1 Y_{74} + \phi_2 Y_{77} + \mu$$

$$(2)\quad \log F = \log \beta_0 + \beta_1 \log P_{fr} + \beta_2 \log O + \beta_3 M + \gamma_1 S_1 + \gamma_2 S_2 + \sigma_1 E_1 + \sigma_2 E_2 + \beta_4 \log H + \beta_5 I + \omega_1 T_\ell + \omega_2 T_o + \alpha D + \beta_5 V + \phi_1 Y_{74} + \phi_2 Y_{77} + \mu$$

where:

F = fertilizer in kgs of nitrogen per ha,

P_{fr} = ratio of fertilizer to rice price,

O = organic fertilizer in kgs per ha,

M = percent of area under modern varieties,

S = dummy variables for quality of soil, where

S_1 = 1 when soil is good for rice production and 0 otherwise,

S_2 = 1 when quality of soil is average and 0 otherwise,

E = dummy variables for elevation of farm, where

E_1 = 1 when farm has a high elevation and 0 otherwise,

E_2 = 1 when farm has average elevation and 0 otherwise,

H = farm sixe in hectares,

C = dummy variables for source of borrowing, where

C_i = 1 when farmer borrowed from informal sources and 0 otherwise,

C_f = 1 when farmer borrowed from formal sources and 0 otherwise.

I = interest rate in percent,

T = dummy variables for tenure, where

T_ℓ = 1 when farmer is a lease holder and 0 otherwise,

T_o = 1 when farmer is an owner operator and 0 otherwise,

D = dummy variable equated to 1 when farmer observed a demonstration plot and 0 otherwise,

V = number of technician's visits,

Y = dummy variable for year, where

Y_{74} = 1 when sample pertains to 1974 and 0 otherwise,

Y_{77} = 1 when sample pertains to 1977 and 0 otherwise,

μ = disturbance term.

As explained below, the two equations differed in the way financial constraint was measured. The demand function was specified on a per hectare basis to separate the effect of scale from the effect of farm size on financial constraint or borrowing limit. Equations 1 and 2 were estimated for the combined sample as well as separately for each year 1971, 1974, and 1977 without the dummy variables for years.

The explanatory variables consisted of prices and variables representing the effect of fertilizer productivity, financial constraints, and extension. The prices of fertilizer and rice were expressed as a ratio to avoid the problem of deflating but this implicitly assumes symmetry of demand response to input and output price changes. Price of organic fertilizer should have been included because a significant amount of organic matter was substituted for chemical fertilizer. In the absence of price data, quantity of organic fertilizer was used. Organic fertilizers were typically by-products of small poultry and hog enterprises owned by the farm and thus may be assumed as an exogenous factor in the demand equation.

Fertilizer productivity is expected to be greater with modern varieties, poorer soils, and low elevation farms and in turn be positively correlated with fertilizer demand. Empirical evidence that modern varieties shift the fertilizer response function upwards are numerous [5, 8]. Soil quality refers specifically to texture. Good rice soils have a high clay content, while poor rice soils are sandy with a low water holding capacity. Areas of high elevation tend to have inadequate water supply since the water drains to the lower fields.

Effective cost of borrowing or opportunity cost of own savings would have been a more appropriate measure of financial constraint but these are not available in our data set. Instead, two alternative variables were used. First, it was hypothesized that source of liquidity (dummy variable for source of loans) may indicate effective cost of working capital. Borrowers from formal sources are expected to pay a lower cost of credit than those who depend on informal lenders. Farmers who do not borrow, on the other hand, may either have enough savings or may be facing a cost of borrowing greater than the marginal return on additional fertilizer. Second, we specified reported interest rate. For those who did not borrow, we arbitrarily assigned the average reported interest rate. Aside from the difficulty of obtaining accurate data on interest rate from informal lenders, this measure does not include borrower's transaction cost which may be significant [1].

Farm size and tenure status indicate availability of own financial resources or alternatively, borrowing limits since lenders may ration credit particularly at institutional interest rates.

Extension influences fertilizer demand through its effect on knowledge of fertilizer productivity. Observation of demonstration plots and frequency of technician's visit represent the extension inputs of the RURP and the Masagana 99 Program, respectively. The dummy variable for year may measure the learning time required to disseminate the fertilizer technology.

EMPIRICAL RESULTS

Fertilizer Demand Functions

The empirical results for the combined and for the separate regressions are reported in Tables 1 and 2, respectively. The regressions generally show significant goodness of fit and the R^2's are moderately high for cross-section data. Except for soil grade and elevation, most of the explanatory variables have statistically significant coefficients; the direction of relationships and values of coefficients are in agreement with expectations.

The ratio of fertilizer to rice price is highly significant and the estimated coefficient is remarkably stable in all runs. Demand for fertilizer is relatively inelastic with respect to price. Price elasticity of fertilizer demand ranges from -.5

TABLE 1: Fertilizer Demand Functions Based on Time Series-Cross Section of Rainfed Farms in Bulacan and Nueva Ecija, Philippines, 1971, 1974, and 1977

Independent Variables	(1)	(2)
Fertilizer/rice price ratio a/	-0.6334 (-7.6796)	-0.6386 (-7.5089)
Organic fertilizer (kg/ha) a/	-0.1892 (-5.1646)	-0.2190 (-5.8431)
Modern varieties (% of area)	0.0074 (5.7747)	0.0089 (6.8800)
Soil grade (medium) b/	0.0100 (0.1000)	0.0294 (0.2881)
Soil grade (high) b/	- .1347 (-1.1824)	-0.1523 (-1.2965)
Elevation (medium) b/	-0.0157 (-0.1789)	-0.0445 (-0.4899)
Elevation (high) b/	0.0252 (0.1854)	0.0155 (0.1101)
Source of liquidity (informal) b/	0.4267 (3.7666)	----
Source of liquidity (formal) b/	0.8845 (6.8497)	----
Interest rate (%)	----	-0.0045 (-2.2928)
Farm size (ha)	0.1353 (1.7810)	0.2080 (2.6868)
Tenure (leasehold) b/	0.2254 (1.9256)	0.2546 (2.1492)
Tenure (owner) b/	0.4201 (3.4278)	0.4374 (3.5519)
Demonstration plot b/	0.2886 (2.6161)	0.3630 (3.2069)
Frequency of visit (no) b/	0.1003 (0.9607)	0.1778 (1.6646)
Year (1974) b/	-0.1174 (-0.8701)	0.0151 (0.1140)
Year (1977) b/	-0.1420 (-1.1091)	-0.2411 (-1.7986)
Constant		
R^2	0.31	0.27

a/ In natural logarithms

b/ Dummy variables

c/ Values in parentheses are t-values

TABLE 2: Fertilizer Demand Functions Based on Cross-Section of Rainfed Farms in Bulacan and Nueva Ecija, Philippines for Each Year - 1971, 1974, and 1977

Independent Variables	1971	1974	1977
Fertilizer/rice price ratio[a/]	-0.8434 (-7.7945)	-0.3453 (-2.1064)	-0.5316 (-3.1688)
Organic fertilizer (kg/ha)[a/]	-0.4080 (-3.2473)	-0.0635 (-1.2763)	-0.2482 (-3.8141)
Modern varieties (% of area)	0.0027 (1.6368)	0.0071 (3.6007)	0.0141 (3.8428)
Soil grade (medium)[b/]	0.0788 (0.5394)	0.0346 (0.2191)	-0.0809 (-0.3742)
Soil grade (high)[b/]	-0.0200 (-0.1225)	0.0183 (0.1000)	-0.4421 (-1.7799)
Elevation (medium)[b/]	-0.0976 (-0.5187)	-0.06911 (-0.3376)	0.1350 (0.4806)
Elevation (high)[b/]	0.0540 (0.2775)	-0.1301 (-0.6277)	0.2337 (0.8155)
Source of liquidity (informal)[b/]	0.5219 (3.4579)	-0.0223 (-0.1000)	0.4721 (2.0484)
Source of liquidity (formal)[b/]	0.4143 (1.9055)	1.1276 (6.1326)	0.6550 (2.2077)
Farm size (ha)	0.2881 (2.6456)	0.1023 (0.8331)	0.0810 (0.4919)
Tenure (leasehold)[b/]	0.5899 (3.4315)	0.2146 (1.2095)	0.0523 (0.1897)
Tenure (owner)[b/]	0.5692 (3.5369)	0.2320 (1.2095)	0.5766 (1.8722)
Demonstration plot[b/]	-----	0.1013 (0.7183)	0.4072 (2.0998)
Frequency of visit [a/]	0.0573 (0.3362)	0.2618 (1.5103)	0.0462 (0.2302)
Constant	3.3400	2.3054	2.0860
R^2	0.38	0.42	0.33

a/ In natural logarithms

b/ Dummy variables

c/ Values in parentheses are t-values

to -.9 which is consistent with other estimates in the Philippines and other Asian countries [5]. The significantly negative coefficient of organic fertilizer per hectare indicate the substitutability of the two factors. If price of organic fertilizer was specified instead, a positive cross-price elasticity would be expected.

The proportion of modern varieties, not type of soil or farm elevation, appears to be the important determinant of fertilizer productivity and thus fertilizer demand among rainfed farms. This is not consistent with the frequently reported superior performance of modern varieties only under irrigated conditions [2].[4/] Our results imply that even under rainfed conditions, modern varieties are more responsive to fertilizer than traditional varieties.

All the variables representing financial constraints are statistically significant. The estimated coefficients of dummy variables for source of liquidity are consistent with the negative relationship between demand for fertilizer and interest rate. Level of fertilizer demand is higher for farmers able to borrow from formal sources characterized by lower cost of borrowing. Lack of liquidity, inability to borrow, or higher effective cost of borrowing appear to constrain fertilizer

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4/ In the Philippines, however, over 50 percent of the rainfed area is now planted to modern varieties. The production increase seems to be due in large measure to the fact that the varieties of shorter growth duration--eg., 100 days for IR36 vs. 130 days for IR8 and 150 days or more for traditional varieties--mature early enough to avoid drought conditions late in the season [2].

application of non-borrowers. The positive relationship of farm size and tenure to fertilizer use per hectare also indicates the importance of financial constraints. It is expected that larger farms, owners, and leaseholders in contrast to small farms and share tenants would have either greater internal savings or more access to lower cost credit.

Observation of demonstration plot appears to be a more effective extension instrument that frequency of visit although the latter is also significant in a number of regressions. This result is not surprising because in the M99 Program, the bulk of extension visits were to facilitate the borrowing from formal loan sources rather than to impart technical knowledge on fertilizer use. The year dummy variable which may indicate the learning time of the fertilizer technology is not only less important but had an unexpected sign. Gascon, *et al*'s, earlier evaluation of the RURP did not find a clear association between the implementation of the project and the change in cultural practice, input use, and especially yield levels. However, the earlier analysis focused mainly on changes in yield over time so that the problem of distinguishing the effect of weather, other natural factors, and the significant changes in the economic conditions during this period was more difficult. This analysis pertains only to fertilizer use which is determined early in the cropping season and explains not only changes over time but also across farms.

The separate yearly regressions showed similar explanatory power for each variable. The pattern of coefficients over time, however, emphasizes the impact of changes in the economic enviroment that could not be adequately captured by the specified variables in the combined regression. In the wet season of 1974 the country was recovering from a 20 percent decline in rice production following two years of bad weather and insect and disease infestation. The problem was aggravated by very tight supplies of fertilizer and quadrupled world fertilizer price due to the oil crisis. The Masagana 99 Program, which linked supervised credit with a substantial fertilizer subsidy, was widely implemented during this time. Since the price subsidy as well as the supply of fertilizer was tied in practice to the participation in the Program, many farmers joined primarily to obtain fertilizer and its price subsidy and only secondarily for credit. Thus, it is very difficult to separate analytically the influence of price, fertilizer availability, extension, and credit in fertilizer demand. The smaller response of fertilizer demand to prices in 1974 is explained by the relative importance of sheer availability of fertilizer as indicated by the higher explanatory power of formal borrowing (or participation in M99) during this year compared to 1971 and 1977. The shift in the significant measure of extension from the demonstration plot in 1971 and 1977 in the combined regressions to frequency of technician's visit which is a part of the Program in 1974, also reflects this confounding problem.

Sources of Fertilizer Demand

Table 3 presents estimates of percentage contributions of each of the statistically significant explanatory factors to the change in fertilizer consumption from 1971 to 1977.[5/] The apparent small change in the rate of nitrogen applied per hectare through time conceals the dynamic economic and policy conditions which occurred during this period. The results generally indicate that prices, modern varieties, and demonstration plots were the major factors affecting fertilizer use. Organic fertilizer also represents the role of price of substitute input as well as substitute technology. Prices showed negative shares as the price of fertilizer relative to prices of output (rice) and substitute input (organic fertilizer) increased. The significant positive contributions of shifts in fertilizer productivity through modern varieties and extension of knowledge of fertilizer technology were not sufficient in reversing this trend.

The expansion of formal sources of credit (Masagans 99 Program) had much less impact over the whole period. The contribution of formal credit in explaining average fertilizer use between 1971 and 1974 was indeed very high. In reality,

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5/ Calculations are based on estimates of equation [1]. A similar pattern of results is observed if the equation [2] estimates are used instead.

TABLE 3: Percentage of Change in Fertilizer Input Per Hectare Due to the Various Explanatory Factors Through Time Among Rainfed Farms in Bulacan and Nueva Ecija, Philippines

Variables	1971-1974	1974-1977	1971-1977
Fertilizer/rice price ratio	- 3	- 8	-11
Organic fertilizer	-26	8	-18
Modern varieties	- 2	13	11
Source of liquidity (informal)	-17	18	- 1
Source of liquidity (formal)	42	-37	5
Farm size	1	- 2	- 1
Tenure (leasehold)	4	3	7
Tenure (owner)	- 2	- 1	- 3
Demonstration plot			14
Frequency of visit			3

this included contributions of price and extension because the Masagana 99 was a very costly package of extension, fertilizer, and credit subsidy. The scarcity value of fertilizer was not reflected in prices but rather in the rationing mechanism for credit. The higher share of frequency of technician's visit in this period also indicated in part the contribution of fertilizer price and credit subsidy which were linked with extension. The significant share of formal credit, however, could not be sustained through 1977 as the percentage of borrowers from formal sources declined from 62 to 20 and the price of fertilizer sought market levels.[6/]

CONCLUSIONS

We have attempted to separate the impact of credit from the other factors affecting fertilizer consumption among rainfed rice farmers in the Philippines. A conceptual framework for analyzing the role of prices, fertilizer productivity, technical knowledge, and financial constraints in explaining fertilizer demand was presented first. Empirical estimates of fertilizer demand functions were then used to calculate the relative contribution of each factor to changes in fertilizer use per hectare from 1971 to 1977. Prices, fertilizer productivity (modern varieties), and extension (demonstration plots) were found to be relatively more important than credit

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6/ Principal reasons were the high cost of the package of subsidies and the low repayment rates on loans.

in accounting for the variations in fertilizer consumption over this period. Estimates of the relative significance of credit about the year 1974 were difficult to interpret because of the tighter linkage of extension and subsidies to credit and fertilizer price during the peak of the Masagans 99 Program.

Our analysis have provided a picture of the relative influence of the various market and policy conditions in the growth of fertilizer demand through time. However, for policy analysis measure of cost-effectiveness is the more relevant criterion in evaluating alternative policy instruments to raise fertilizer consumption and hence rice production.

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